Edge:
Canny

Dr. Tushar Sandhan

Introduction

- Single point thick edges

input

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Canny edges

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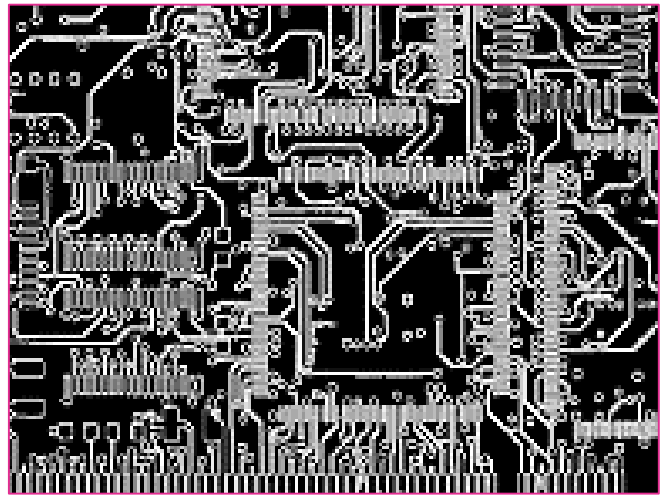
Canny edges



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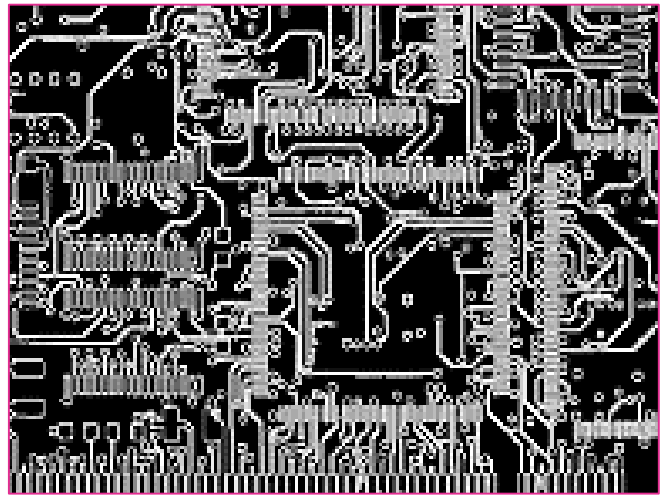

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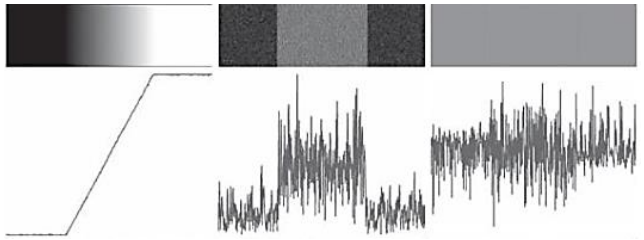

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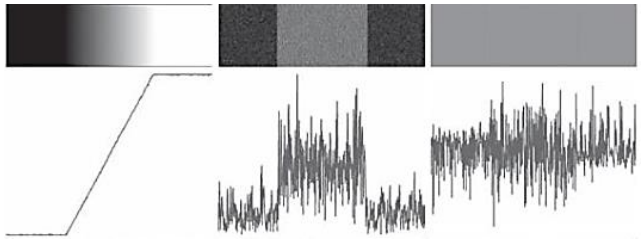

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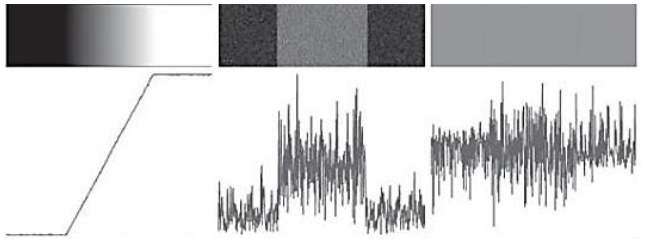

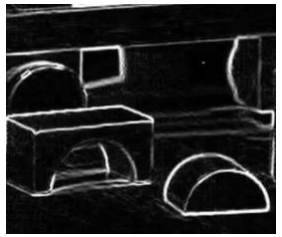

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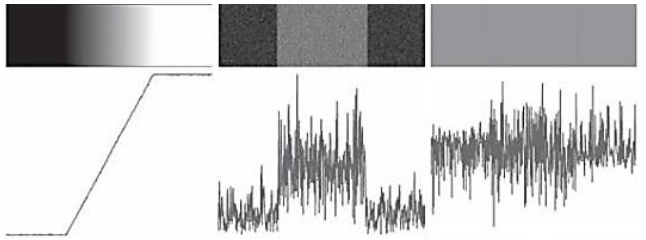

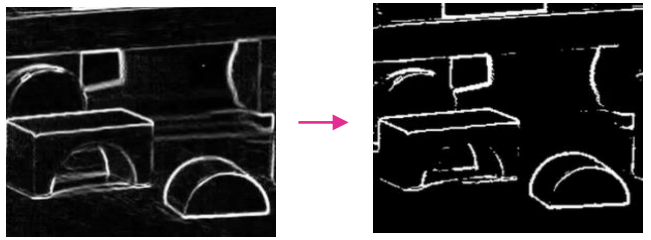

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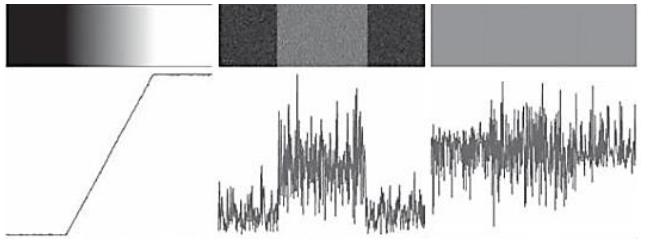

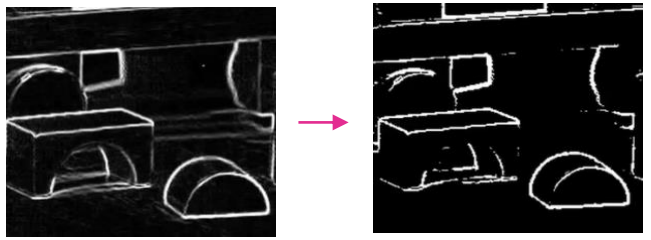

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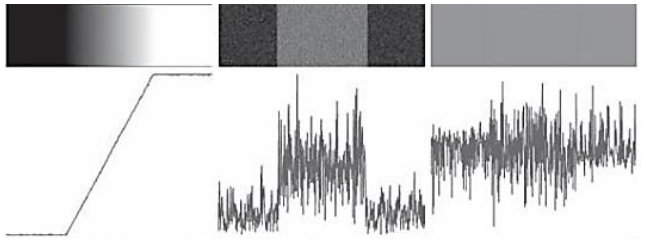

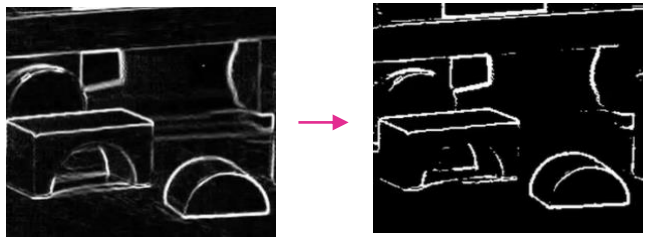

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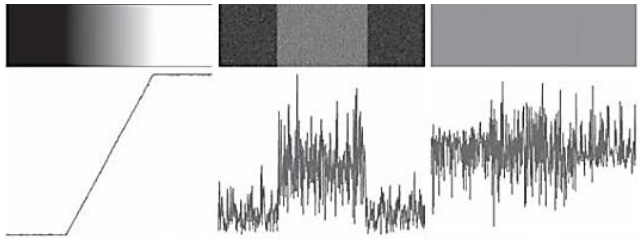

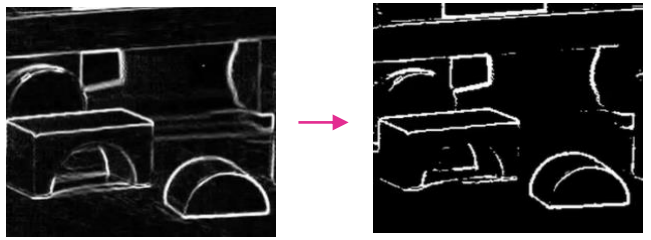

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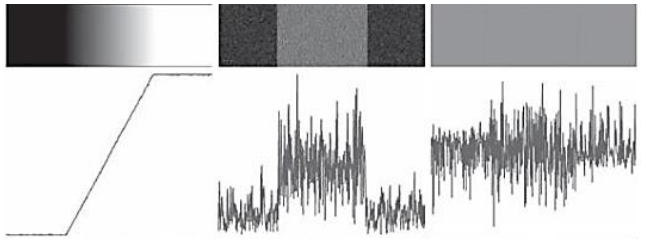

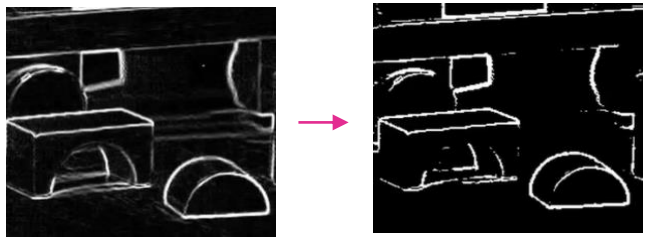

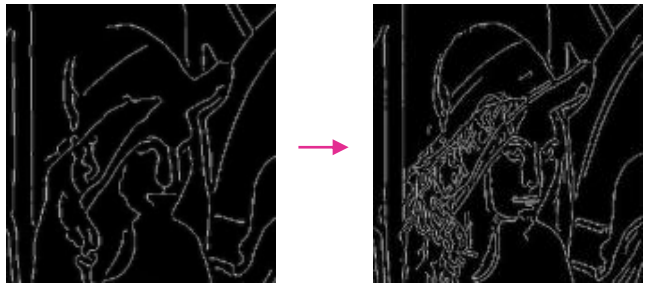

Canny edge detector

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    - minimize the distance $\|c_i - e_i\|_2$
  - single point edge response
    - 1 point for each true edge point

Canny edge detector

- Image derivatives
  - input image $f(x, y)$
  - smoothed $f_s(x, y)$
  - any operator can be used to get $g_x(x, y)$, $g_y(x, y)$

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Canny edge detector

- Thinning
  - $M_s(x,y)$ wide ridges around local maxima
  - ridges thinning is needed
  - non-max suppression
    - suppress where?

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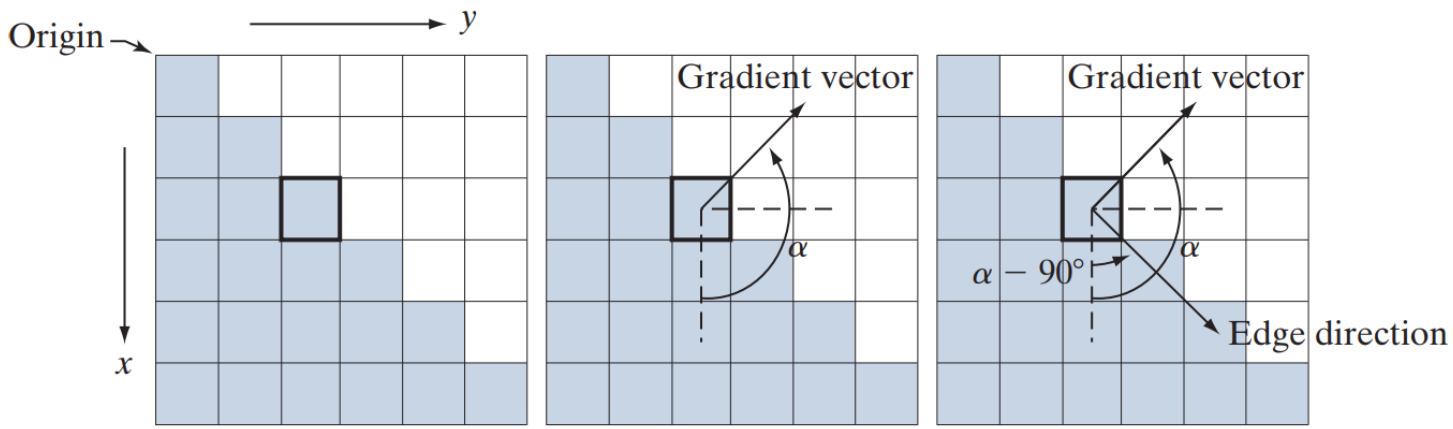

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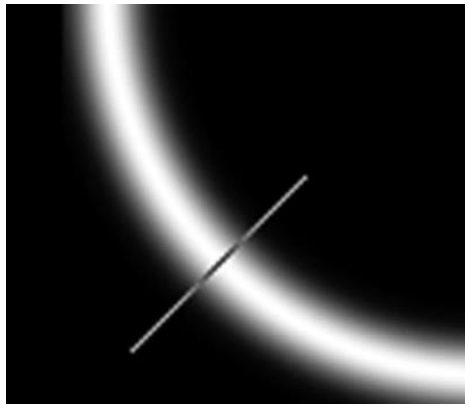

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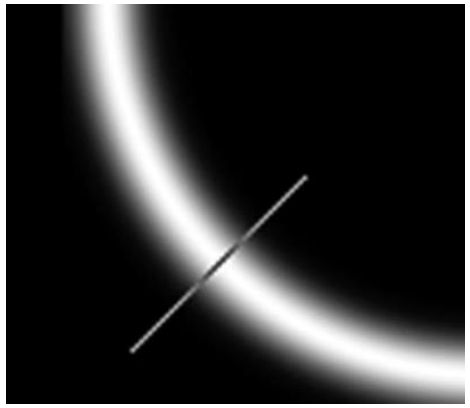

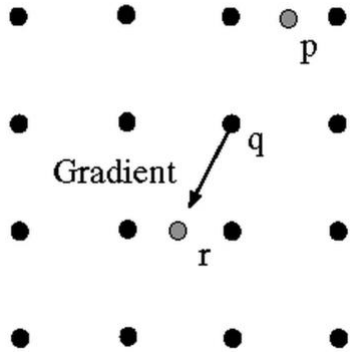

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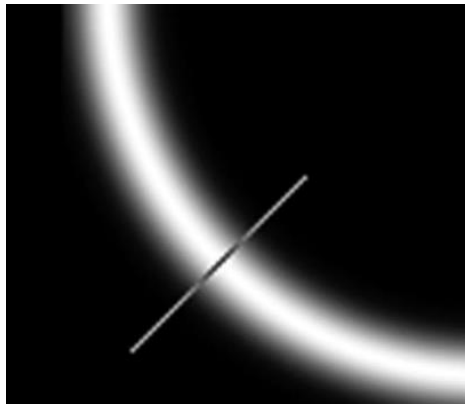

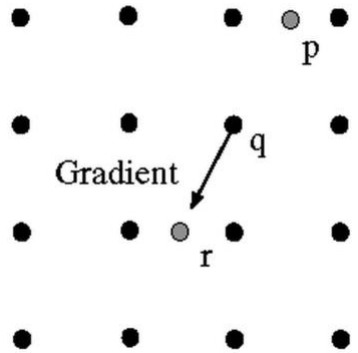

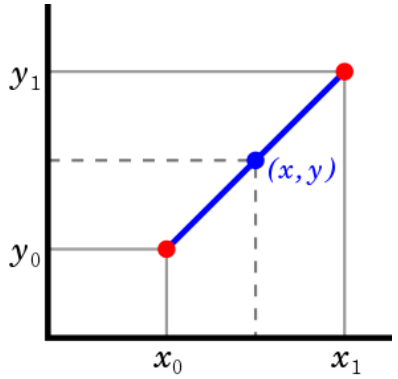

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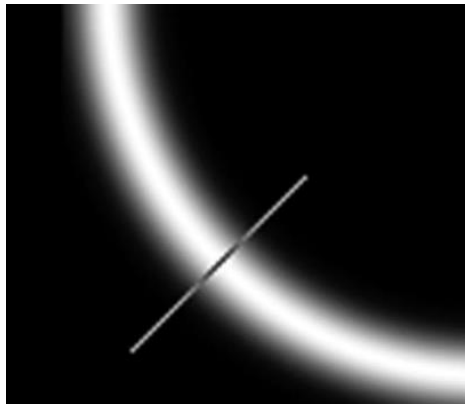
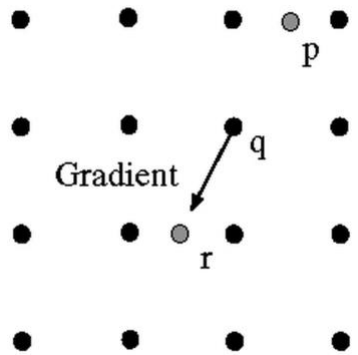
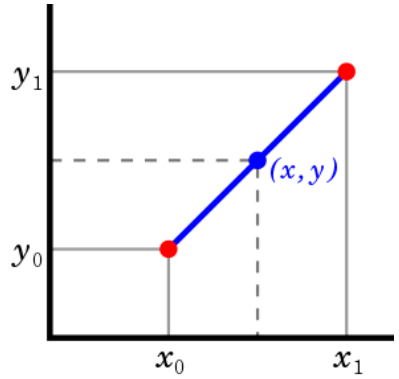




$$\frac{y - y_0}{x - x_0} = \frac{y_1 - y_0}{x_1 - x_0}$$



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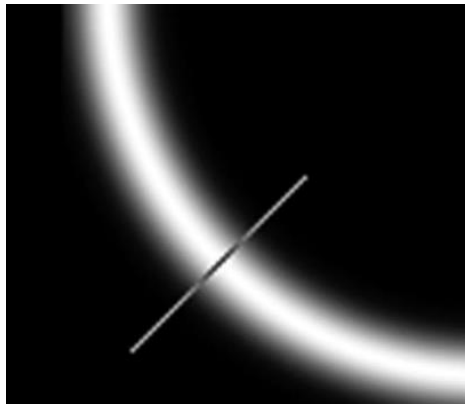

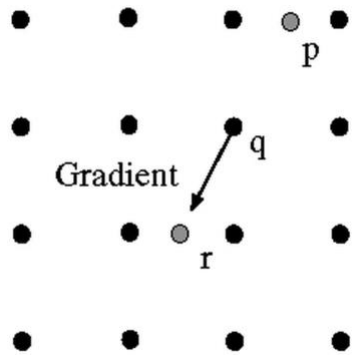

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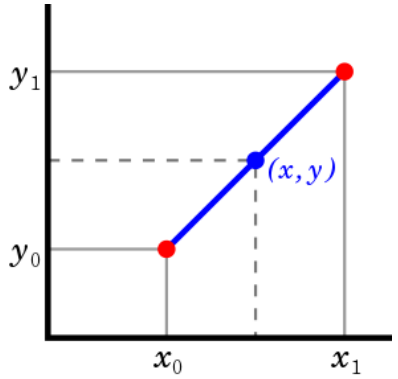

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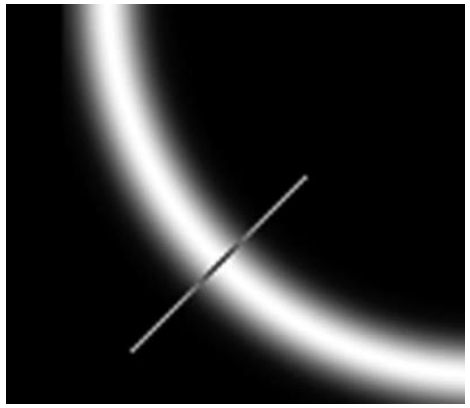

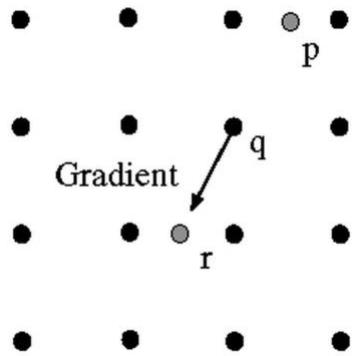

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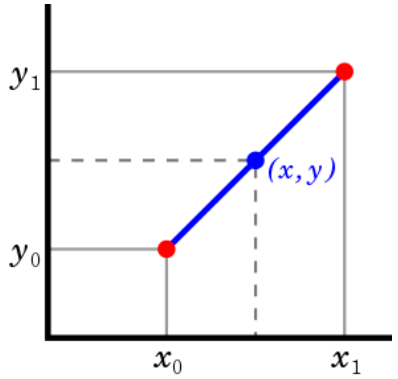
$$= y_0 \left(1 - \frac{x - x_0}{x_1 - x_0}\right) + y_1 \left(\frac{x - x_0}{x_1 - x_0}\right)$$



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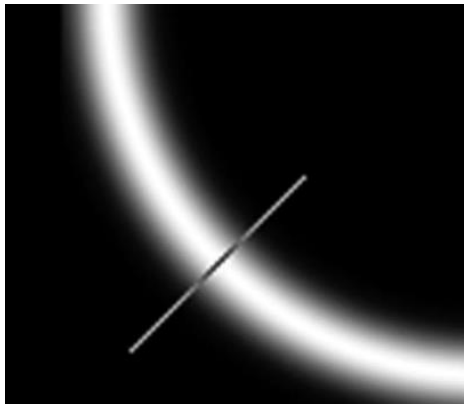

Canny edge detector

- LINKING Points
  - Canny edge detector
    - It starts with one thing: gradients
    - In the end, it doesn't even matter: which operators have been used
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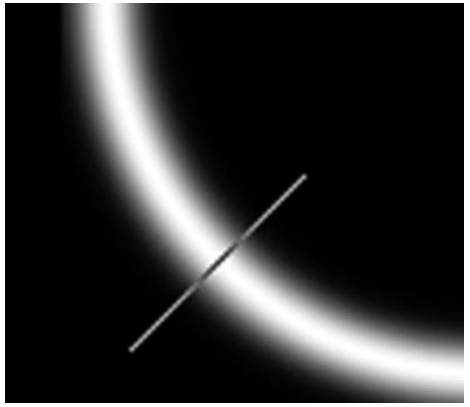

Canny edge detector

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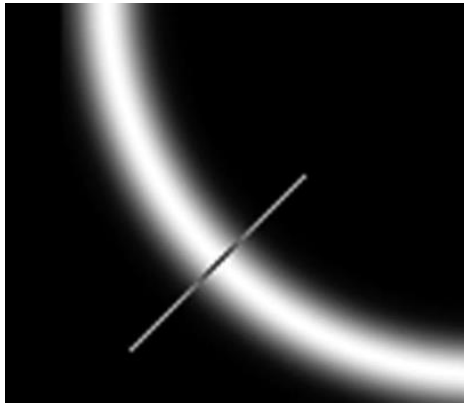

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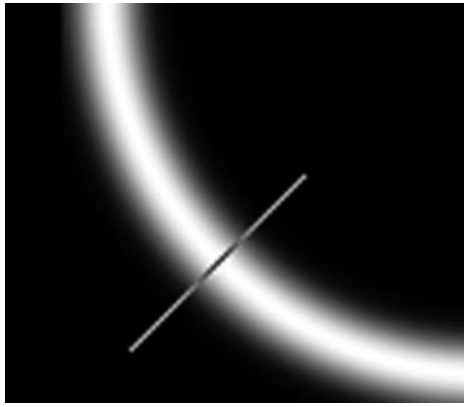

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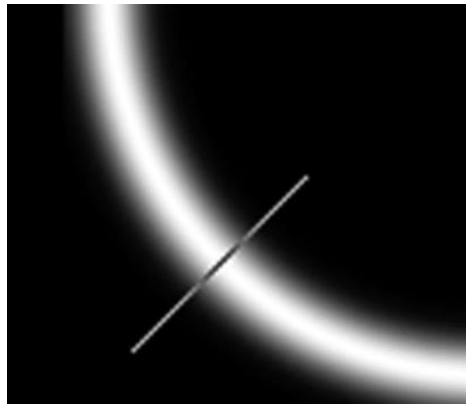

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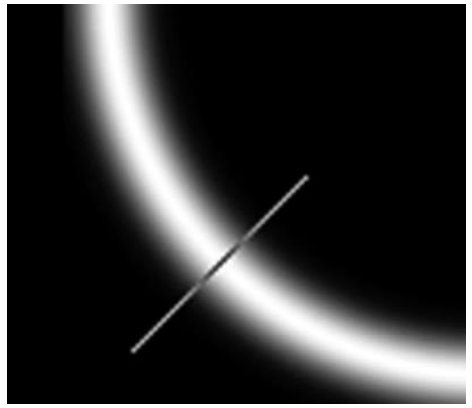

  - two instruments of thresholds: Hysteresis

    a. find all edge points using TH^{high}
    b. from each strong point follow the both side direction $\perp$ to the edge normal
    c. in that directions, construct the contours of connected edge points
    d. mark all points greater than TH_{low}

Canny edge detector

- Entire algorithm composition:

Canny edge detector

- Entire algorithm composition:

1. Filter image with derivatives of Gaussian
2. Get M, α
3. Non-max suppression
   - thin multi-pixel wide edges to a single pixel widths
4. Linking: the hysteresis
   - 2 thresholds: TH_{low} , TH^{high}
   - TH^{high}: to start an edge
   - TH_{low} : continue started edge

Canny edge detector

Canny edge detector

- Speeding up the beats of operations
  - binning the α (angles)
  - 4 directions

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    Horizontal

    +45 degrees

    Vertical

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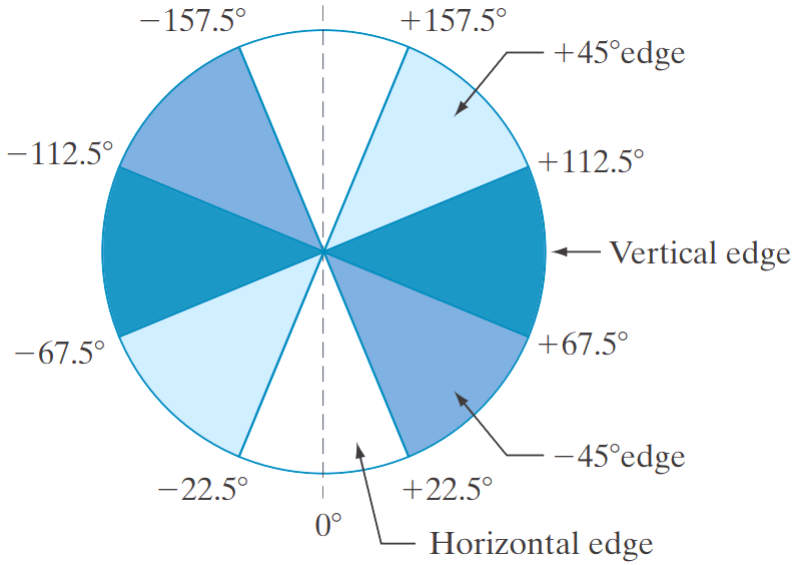

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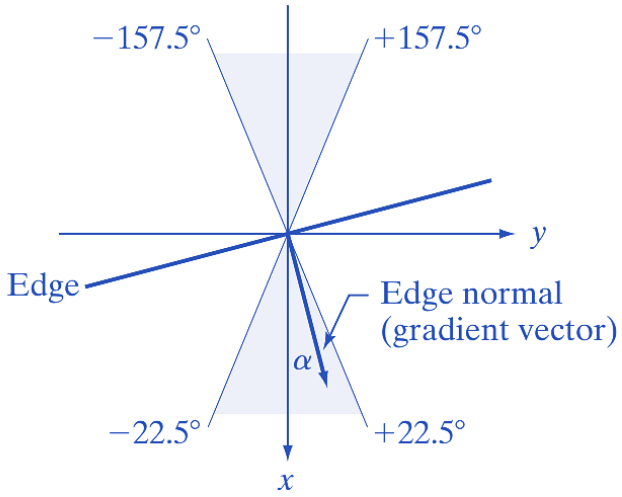
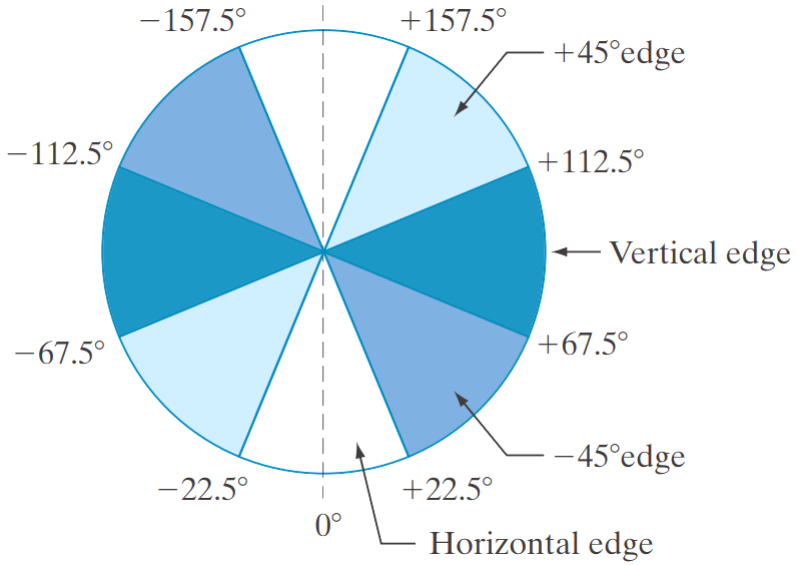
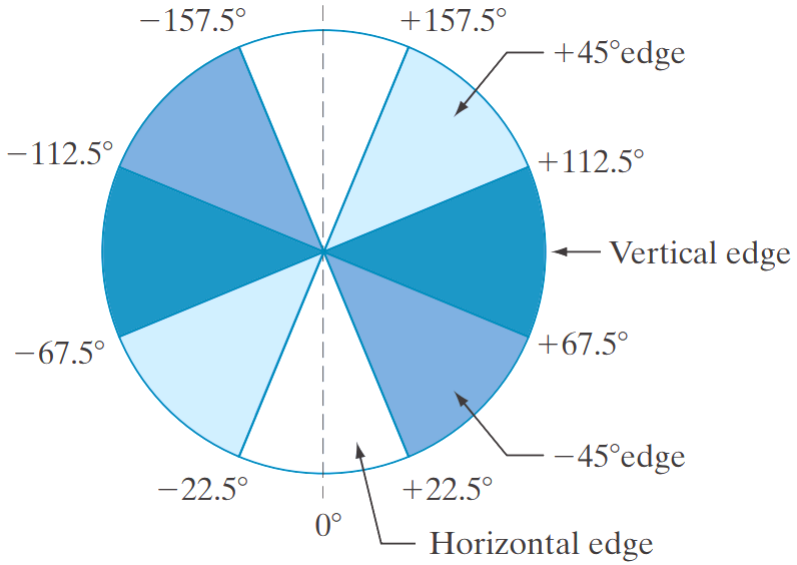




Canny edge detector

- Speeding up the beats of operations
  - binning the α (angles)
    - get the directional bin $Bin()$ closest to α
    - from previous operations edge: $M(x, y)$
    - suppression
      - If $M(x', y') > M(x, y)$ then

        $M(x, y) \rightarrow 0$
      - where neighbors $x', y' \leftarrow Bin(x, y)$



Canny edge detector

- Varying σ

input

Canny edge detector

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Canny edge detector

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input

σ small

Canny edge detector

- Varying σ

input

σ small

σ large

Canny edge detector

- Comparing other edge detectors

input

Canny edge detector

- Comparing other edge detectors

input

Sobel with TH

Canny edge detector

- Comparing other edge detectors

input

Sobel with TH

LoG zero crossings

Canny edge detector

- Comparing other edge detectors

input

Sobel with TH

LoG zero crossings

Canny

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input

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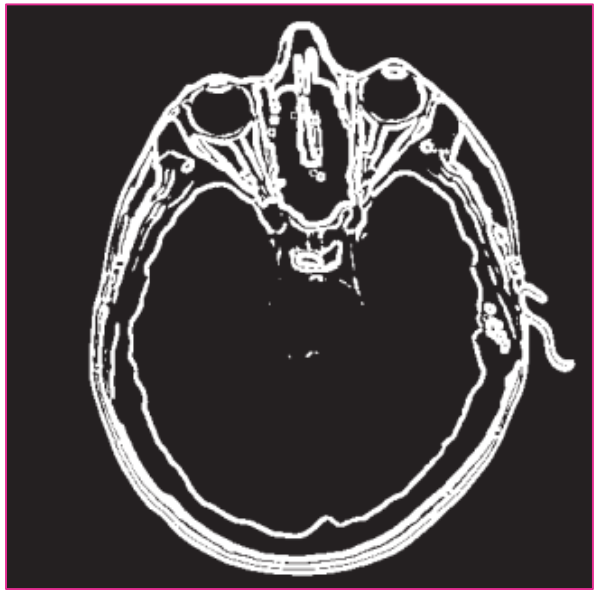
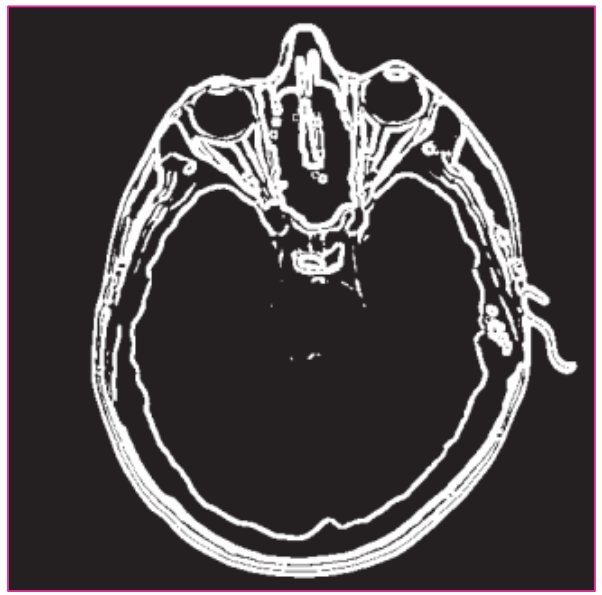


Canny edge detector

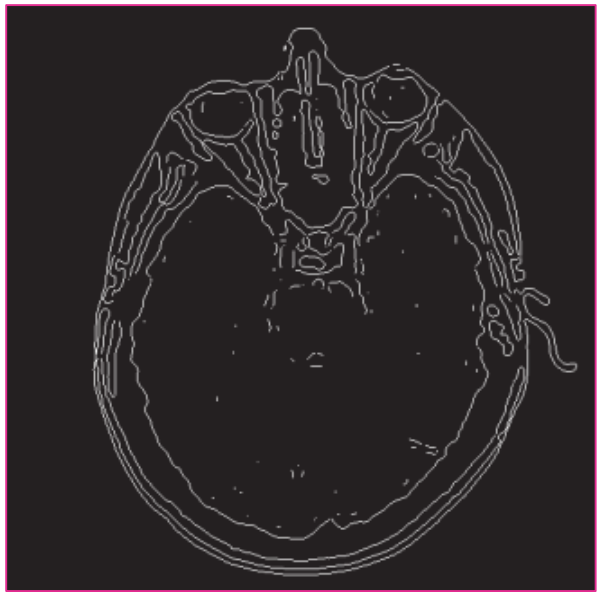
- Comparing other edge detectors

input

Sobel with TH



LoG zero crossings



Canny edge detector

- Comparing other edge detectors

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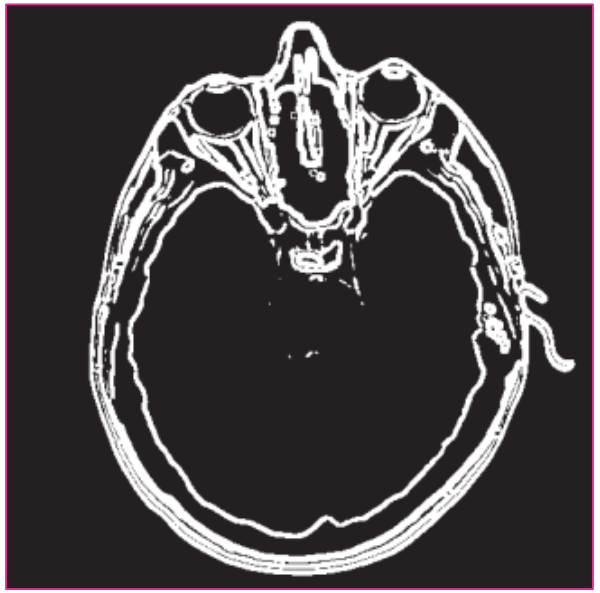
Sobel with TH



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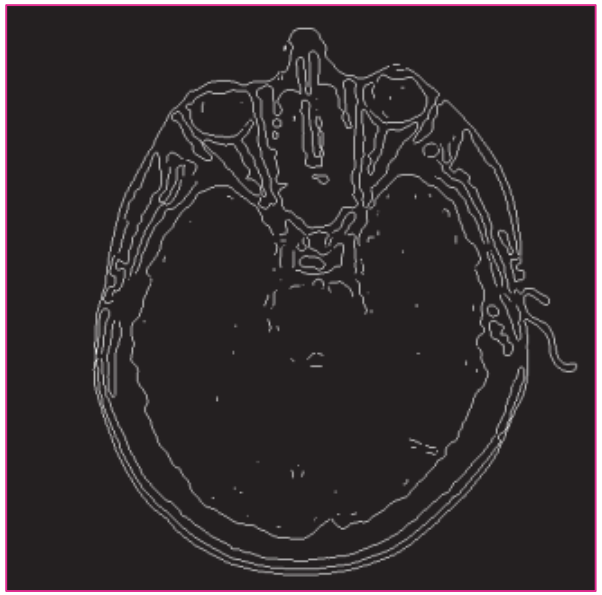

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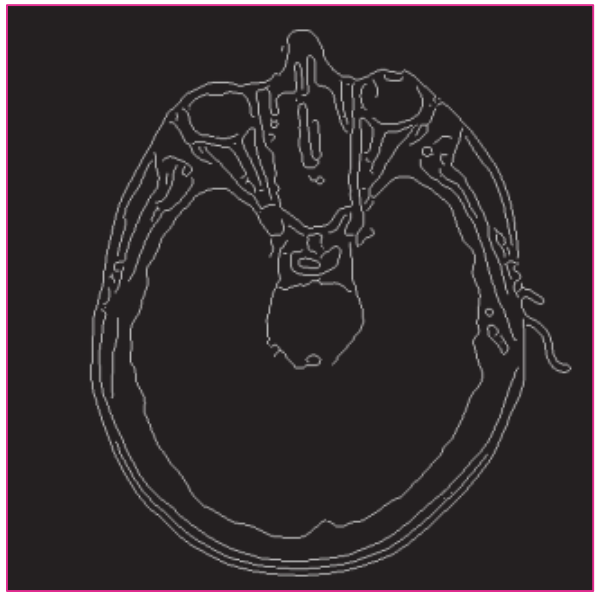

A canny player with a Canny edge!

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Messi

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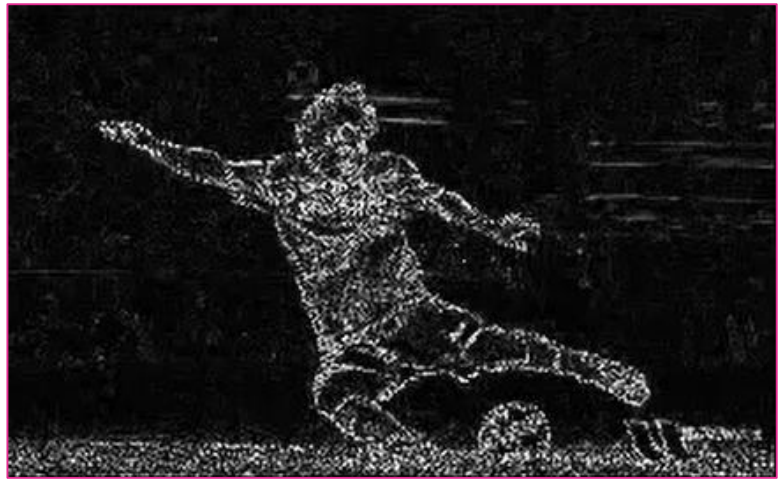

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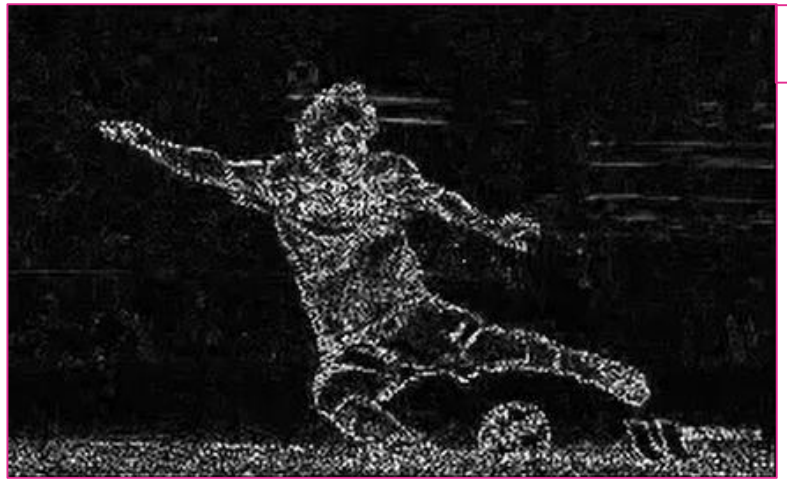

Laplacian

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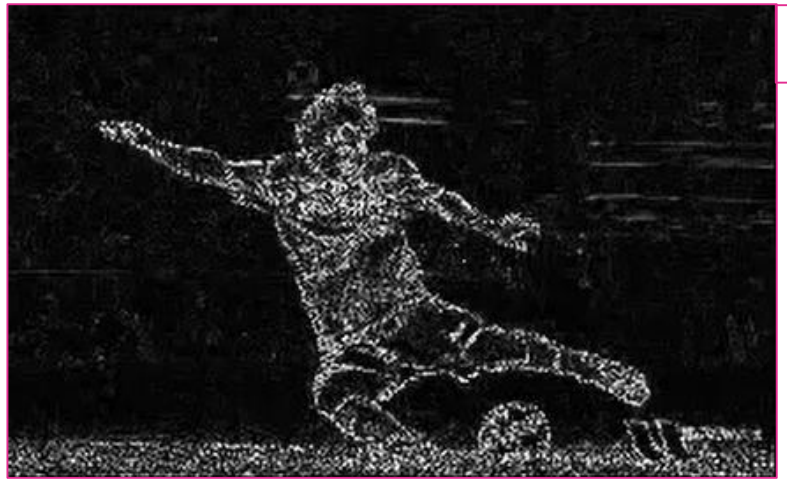

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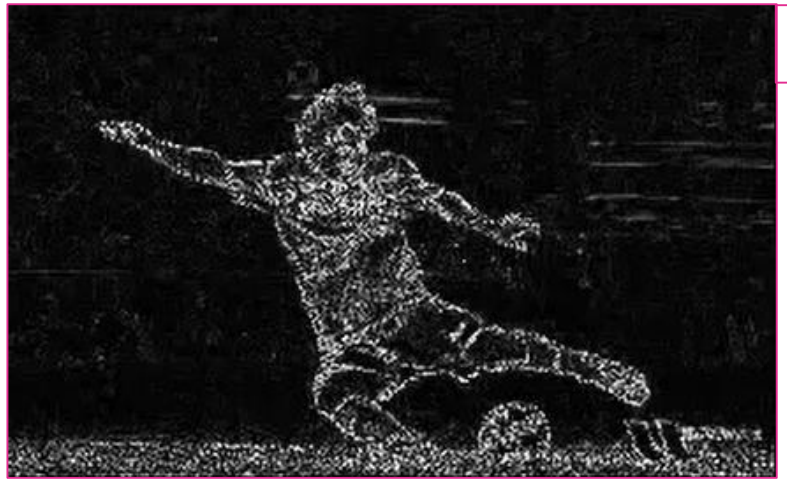

Laplacian

Canny

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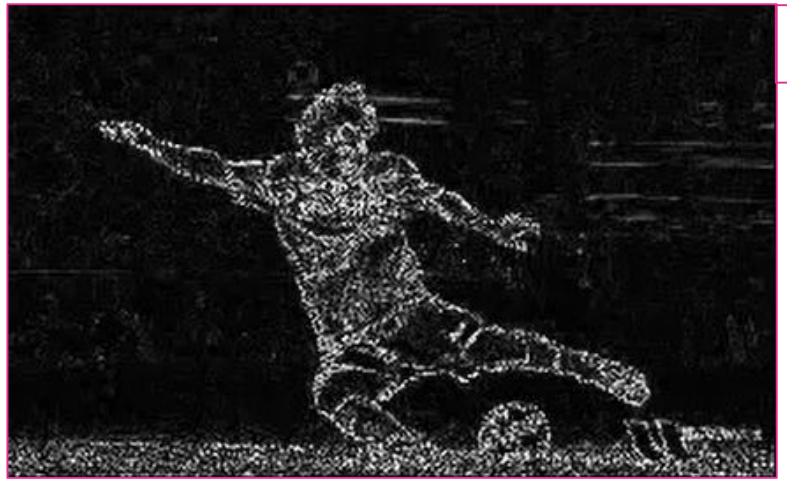
Messi

who will you go with?

Sobel



Laplacian

Canny

Conclusion

- Canny edge detector

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- Single point thick edges

- Canny operations
  - Thinning: non-max suppression
  - Linking: double TH hysteresis
  - High accuracy is paid via computational expenses

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